Designing complex architectured materials with generative adversarial networks

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Abstract

Complex architectured materials are designed with generative adversarial networks to approach Hashin-Shtrikman upper bounds. Architectured materials on length scales from nanometers to meters are desirable for diverse applications. Recent advances in additive manufacturing have made mass production of complex architectured materials technologically and economically feasible. Existing architecture design approaches such as bioinspiration, Edisonian, and optimization, however, generally rely on experienced designers' prior knowledge, limiting broad applications of architectured materials. Particularly challenging is designing architectured materials with extreme properties, such as the Hashin-Shtrikman upper bounds on isotropic elasticity in an experience-free manner without prior knowledge. Here, we present an experience-free and systematic approach for the design of complex architectured materials with generative adversarial networks. The networks are trained using simulation data from millions of randomly generated architectures categorized based on different crystallographic symmetries. We demonstrate modeling and experimental results of more than 400 two-dimensional architectures that approach the Hashin-Shtrikman upper bounds on isotropic elastic stiffness with porosities from 0.05 to 0.75.